A longitudinal study of the knee adduction moment components post-arthroscopic partial meniscectomy

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INTRODUCTION

Following medial arthroscopic partial meniscectomy (APM), patients are at increased risk of developing knee osteoarthritis in the longer-term [1]. Higher medial knee joint loading during gait post-APM is thought to contribute to this increased risk of osteoarthritis. The external knee adduction moment (KAM) is often used as a proxy for dynamic medial knee joint loading and has been found to be higher in patients post-APM surgery as compared to healthy controls [2,3]. Furthermore, we have recently found that over 2 years (from 3-months post-APM surgery), the peak KAM during normal paced walking increased by 9% [2]. The KAM is largely derived as a product of the knee-ground reaction force (GRF) lever arm, and the resultant frontal plane GRF magnitude. For researchers aiming to reduce the KAM post-APM, it is of value to understand which components of the KAM likely contribute to the increase in medial knee joint loads over time in people post-APM.

In individuals measured 3 months post-medial APM (baseline) and 2-years later (follow-up), the purpose of this investigation was to determine: 1) if the knee-GRF lever arm and frontal plane GRF magnitude increased over time; 2) the correlation between the change in peak KAM and a) change in knee-GRF lever arm and b) change in frontal plane GRF magnitude; 3) how much of the variation in change of peak KAM over time is explained by the change in knee-GRF lever arm and the change in frontal plane GRF magnitude.

METHODS

This is a secondary analysis of data collected in a longitudinal study that described and compared the KAM and knee muscle strength in APM participants and healthy controls [2]. Data from 65 individuals with medial APM were collected at baseline 3 months after surgery (86% male; 41 ± 5 yrs; BMI 27.3 ± 4.2 kg/m²) and 2 years later at follow-up (86% male; age 41 ± 6 yrs; BMI 27.3 ± 4.6 kg/m²) were analyzed.

Participants walked barefoot at a self-selected normal pace while kinematic data (120Hz) were collected using an eight-camera motion analysis system (Vicon) with kinetic data (1080Hz) recorded using three force plates (AMTI), using the UWA model. The two primary determinants of the KAM; the knee-GRF lever arm and resultant frontal plane GRF were determined at the time of peak KAM by a custom BodyBuilder model (Vicon, Oxford, UK). Specifically, the knee-GRF lever arm was calculated as the perpendicular distance between the frontal plane GRF vector and knee joint center of rotation, and the frontal plane GRF magnitude was defined as the resultant magnitude of GRF vector in laboratory frontal plane [4]. The knee-GRF lever arm and frontal plane GRF magnitude were averaged over five trials. The knee-GRF lever arm was normalized to body height and the frontal plane GRF magnitude was normalized to body weight.

Paired t-tests were used to determine whether the knee-GRF lever arm and the frontal plane GRF changed over time. For variables that significantly changed over time, relationships between their change and change in the peak KAM were determined using Pearson correlation. Forced entry regressions were then used to determine how much variation in the change in peak KAM was explained by change in knee-GRF lever arm, change in frontal
RESULTS AND DISCUSSION

As previously reported, the peak KAM showed a significant 9% increase over the 2 years [2]. Paired t-tests also identified significant increases of 3.4% for the knee-GRF lever arm (p=0.016) and 1.6% for the frontal plane GRF magnitude (p=0.042) in this post-APM cohort. Significant positive correlations were found between the change in peak KAM and each of the change in knee-GRF lever arm (Figure 1), and change in frontal plane GRF magnitude (r = 0.371; p = 0.003). Regression results indicate that change in knee-GRF lever arm was a moderate predictor of the change in peak KAM (R² = 0.286, p <0.001). The change in frontal plane GRF magnitude was a weak predictor of the change in peak KAM (R² = 0.138, p = 0.003). Together the predictability of the model improved, with change in change in knee-GRF lever arm and frontal plane GRF contributing 36% to the change in peak KAM post-APM (R² = 0.357, p < 0.001).

Figure 1. Relationship between change in peak KAM and change in knee-GRF lever arm. KAM: knee adduction moment; GRF: ground reaction force; ht: body height; BW: body weight

Given the association between a higher peak KAM and cartilage degeneration and osteoarthritis progression [5] it is clinically important to investigate the mechanisms underpinning the increases in the peak KAM post-APM surgery. These findings suggest that both the knee-GRF lever arm and frontal plane GRF magnitude could be targeted to potentially reduce peak KAM over time post-APM, although reasons for the increases in knee-GRF lever arm and frontal plane GRF magnitude over time cannot be determined in the current study. Potential factors could include impaired lower limb joint stability and upper body neuromuscular control following APM surgery. The regression analysis results suggest that reducing the knee-GRF lever arm may have greater impact. The knee-GRF lever arm is a function of greater “medial leaning” GRF vector in the frontal plane and/or varus posture of the knee. Three ways to reduce this would be i) more laterally directed acceleration of the upper body centre of mass, ii) greater lateral trunk lean to move the upper body centre of mass relatively closer to the knee, and/or iii) by changing the posture of lower limb so that the knee is located more medially (i.e. greater knee and hip flexion with greater hip internal rotation). A number of conservative interventions such as shoes, braces, gait retraining and/or neuromuscular exercises may potentially help to reduce increases in knee-GRF lever arm post-APM.

CONCLUSIONS

This longitudinal study identified that the increase in peak KAM post-APM is explained by increases in both each of its primary determinants (knee-GRF lever arm and frontal plane GRF magnitude). Further investigation is required identify the mechanisms underlying these changes and to investigate whether postural modifications can help reduce peak KAM in the post-APM population.

REFERENCES